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THE

Connecticut Agricultural Experiment Station.

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THE BABCOCK METHOD OF DETERMINING FAT IN MILK
AND MILK PRODUCTS.

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NOTICE AS TO BULLETINS.

The Bulletins of this Station, usually issued quarterly or oftener, are mailed free to citizens of Connecticut who apply for them, and to others, as far as the limited editions permit.

Applications should be renewed annually before January 1st.

The matter of all the Bulletins of this Station in so far as it is new and of permanent value will be made part of the Annual Report of the Director.

Bulletins earlier than No. 71 and Nos. 83, 93, 100, 101, 102, 109 and 111 are exhausted and cannot be supplied.

NOTICE AS TO SUPPLY OF STATION REPORTS.

The Station has no supply of its Annual Reports for the years 1877, 1878, 1879, 1880, 1881, 1883, 1887, and 1891.

The Annual Report of this Station, printed at State expense, is by law limited to an addition of 12,000 copies, of which 5,000 copies are bound with the Annual Report of the Connecticut State Board of Agriculture, and distributed by the Secretary of the Board, T. S. Gold, West Cornwall, Conn.

After exchanging with other Experiment Stations and Agricultural Journals, the Reports remaining at the disposal of the Station will be sent to citizens of Connecticut who shall seasonably apply for them, and to others as long as the supply lasts.

THE BABCOCK METHOD OF DETERMINING THE PROPORTION OF FAT IN MILK AND MILK PRODUCTS.

This method is based on the fact that when milk is mixed in proper proportions with sulphuric acid of a certain strength the acid dissolves or mixes with all the milk-ingredients except the butter-fat. Then with suitable apparatus the butter-fat is completely brought to the surface and accurately measured.

The quantity of butter-fat shown by the Babcock method, is now the basis of payment for milk or cream in many of the most successful creameries east and west. The use of this method, which is unquestionably more satisfactory than any other now known that can be used on the farm or in the creamery, is rapidly increasing and promises to become almost universal.

In Bulletin 106 of this Station, issued in 1891, the attention of Connecticut dairymen was called to the method. The supply of that Bulletin has, however, long been exhausted. To answer inquiries more frequently made of late regarding the way to work the Babcock test, is the object of this Bulletin. In its preparation full use has been made of Bulletin 36, of the Wisconsin Experiment Station, written by Dr. Babcock.

Directions are first given for sampling milk and its products. Then follow instructions for preserving samples which cannot be immediately tested, and lastly the method of executing the tests is fully described.

WEIGHT OF THE MILK.

To determine the quantity of butter-fat which a cow daily produces it is absolutely necessary in the first place to know the quantity of milk which she gives.

Weigh the milk accurately at milking time, which may be conveniently done on a spring balance in a pail which weighs an even number of pounds.* If the milk cannot be weighed, the

* The pail may be brought to the required weight by soldering the necessary amount of lead on the outside.

number of quarts multiplied by 2.15 will give its approximate weight. Thus: $8\frac{1}{2}$ quarts is pretty nearly $(8\frac{1}{2} \times 2.15) = 18.3$ pounds.

The measuring must be accurate. Froth is not milk. A quart measure filled to a quarter of an inch of the top is not a quart. An "eight quart" pail sometimes holds considerably less or more than eight quarts.

DIRECTIONS FOR SAMPLING WHOLE MILK.

Milk of Single Cows.—Milk that has soured or on which cream has risen and dried, so as to form a clot or skin, cannot be accurately sampled on the farm.

Thoroughly mix the milk, as soon after milking as possible, either by pouring three or four times from one pail to another, or by stirring vigorously with a dipper. To secure an accurate sample, thorough mixing is absolutely essential. Failure to secure a fair sample makes the test worthless or worse than worthless. Immediately after mixing, dip out a sample of about one half gill or two ounces. From this a sample may be at once measured in the way to be described later for testing, or the whole quantity may be put into a *clean and dry* bottle,* with a preservative when necessary, and kept till used in a cold place where it will not freeze.

Mixed Milk of a Herd.—Into some vessel like a cream carrier, pour all the milk from the pails or cans *at one time*, and from such a height that the whole quantity is stirred up from the bottom. Then with a cup, dipper or pitcher, *at once* take out about a pint. Stir this thoroughly with a spoon immediately before pouring into the sample bottle, or before measuring the quantity for the Babcock test. If there is no can at hand large enough to hold the whole lot of milk, very accurate sampling is not possible. Still if the milk is in a number of cans or pails of the same size or shape, and all have the same quantity of milk in them, a pretty fair sample may be got by taking the same quantity of milk, a gill, pint or quart, from each can or pail, after thorough stirring as already described, mixing these samples thoroughly, and then taking a single sample from the mixture.

* Rather than try to use large bottles or those not perfectly clean it is better to buy from a druggist new two-ounce bottles with new corks.

Skim-Milk and Butter-Milk.—The same course should be followed as with the mixed milk of a herd. The *whole quantity* of the skim-milk or butter-milk should be mixed. The sample must not be taken from a part of it. If possible weigh the skim-milk or the butter-milk. Then from this weight and the per cent. of fat the whole loss of butter-fat can be calculated.

Cream.—Cream that is very thick, clotted or soured cannot readily be sampled on the farm. The same is true of centrifugal cream when it is badly frothed; but sweet cream thin enough to pour freely, may be sampled in the same way as whole milk, after pouring it two or three times from one vessel to another.

PRESERVATION OF SAMPLES TO BE SUBSEQUENTLY TESTED.

Potassium bichromate will keep milk from souring, and in proper condition for testing for some time. Although poisonous, it is by no means so violent a poison as corrosive sublimate, which some have recommended, and may be used with comparatively little danger. It gives to milk an orange yellow color easily distinguishable from pure milk, which lessens the danger from its use. Packages containing this material and samples of milk preserved by it should, however, always be labelled "Poison." To every half gill (2 ounces) of milk add about one grain of powdered potassium bichromate and shake the bottle till it is dissolved and evenly mixed. The quantity used need not be weighed as the amount may vary considerably without affecting the results. As much of the pulverized bichromate as equals a buckshot in bulk will suffice. Keep the samples in a cool place if possible.

APPARATUS FOR THE BABCOCK METHOD.

Test Bottles.—The test bottles used for whole milk (figure 1) have graduations from 0 to 10, each division of the scale representing 0.2 per cent. These bottles can be used also for skim-milk and butter-milk, but a bottle which holds twice as much and has a scale graduated to 0.1 per cent. (shown in figure 2) admits of more accurate work with skim-milk or butter-milk.

Of the several bottles which have been recommended for testing cream, we prefer for practical dairy work, one devised at this Station. It has a neck of wider bore than the milk bottles,

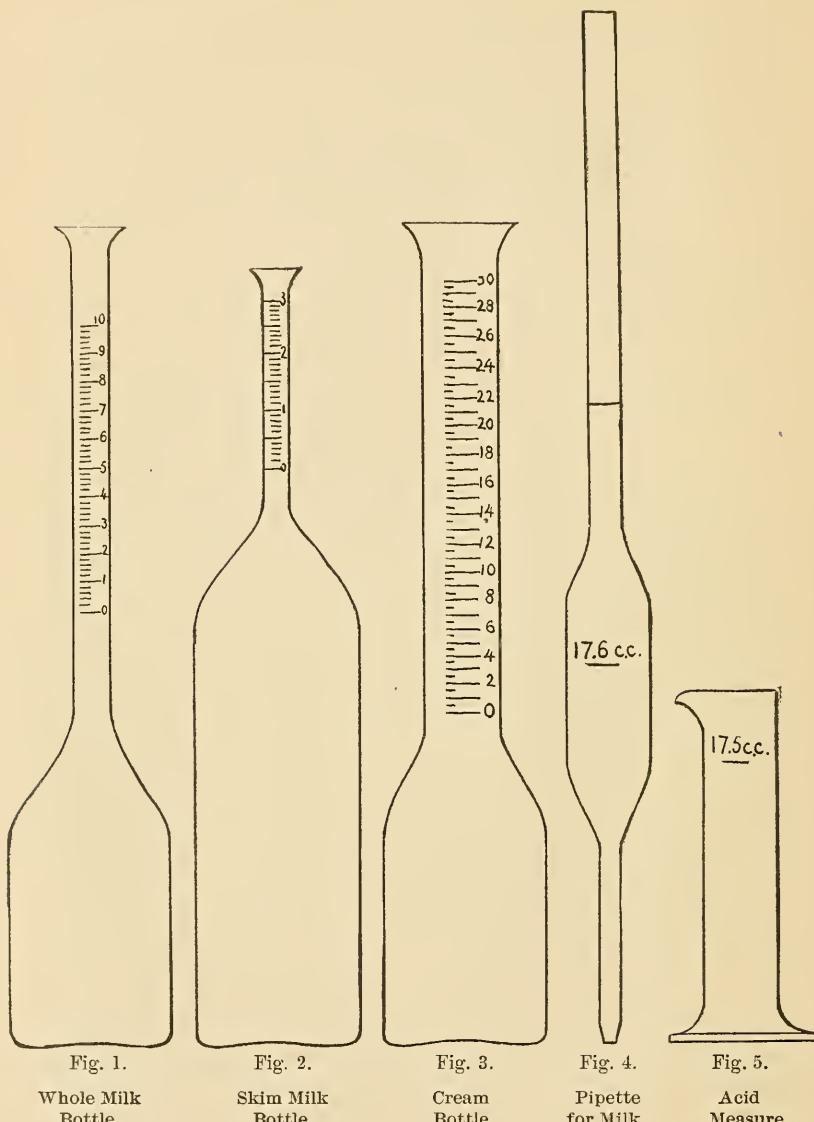


Fig. 1. Whole Milk Bottle. Fig. 2. Skim Milk Bottle. Fig. 3. Cream Bottle. Fig. 4. Pipette for Milk. Fig. 5. Acid Measure.

graduated from 0 to 30 (figure 3). The graduated portion of the neck is about the same length as that of the whole milk bottles, but has three times its capacity. The divisions of the scale represent 0.5 per cent., but can be read to a quarter of a division.

Owing to the lower specific gravity of cream, 18 cubic centimeters of it are used instead of 17.6 c.c., as in the case of milk.

Pipettes.—For whole milk, skim-milk and butter-milk a pipette delivering 17.6 cubic centimeters is used (figure 4). When skim-milk and butter-milk are tested in bottle No. 2, the pipette is filled twice, that is to say 35.2 c.c. are used for the test. An 18 c.c. pipette must be used with the cream bottle.

Acid Measure.—This is a glass graduate which holds, when filled to the mark, 17.5 c.c. See fig. 5.

Centrifugal Machine.—There are machines of various patterns put on the market by manufacturers of dairy supplies, all of which are suitable for the purpose. The sizes vary from four bottle testers to those carrying fifty or more bottles, the larger being designed for factory use. The wheel to whose circumference the bottles are attached should make from 700 to 1200 revolutions per minute according to its diameter, about 700 revolutions being sufficient for the larger wheels with a diameter of about 20 inches, while small 12-inch wheels should run at the rate of about 1200 revolutions per minute.

Commercial Sulphuric Acid (Oil of Vitriol).—This should have a specific gravity of 1.82. If much stronger, the fat will be of a dark color; if weaker it will be contaminated with undissolved curd. The acid should be kept in tightly stoppered bottles, as otherwise it rapidly absorbs moisture from the air and becomes too weak. The stopper should be of either glass or rubber, and not of cork which is rapidly destroyed by the acid. This oil of vitriol is extremely corrosive. It will ruin very quickly clothing or leather on which it falls, and soon makes painful burns if in contact with the skin. If the hands come in contact with it they should be immediately and thoroughly rinsed. The greatest care must be used in handling it.

MAKING THE TEST.

The details of the process of testing are the same for whole milk, skim-milk, butter-milk and cream (except as far as the quantities for testing, and the form of the bottles is concerned) and are best described substantially in Dr. Babcock's own words as follows :

Measuring the Milk.—The pipette is filled by placing its lower end in the milk and sucking at the upper end until the milk rises above the mark on the stem; then remove the pipette from the mouth and quickly close the tube at the upper end by firmly pressing the end of the fore-finger upon it to prevent access of air. So long as this is done the milk cannot flow from the pipette. Holding the pipette in a perpendicular position, with the mark on a level with the eye, carefully relieve the pressure on the finger so as to admit air slowly to the space above the milk. In order to more easily control the access of air both the finger and end of the pipette should be dry. When the upper surface of the milk coincides with the mark upon the stem, the pressure should be again applied to stop the flow of milk. Next, place the point of the pipette in the mouth of one of the test bottles, held in a slightly inclined position so that the milk will flow down the side of the tube leaving a space for the air to escape without clogging the neck, and remove the finger allowing the milk to flow into the bottle. After waiting a short time for the pipette to drain, blow into the upper end to expel the milk held by capillary attraction in the point. If the pipette is not dry when used it should be filled with the milk to be tested, and this thrown away before taking the test sample. If several samples of the same milk are taken for comparison, the milk should be poured once from one vessel to another after each sample is measured. Neglect of this precaution may make a perceptible difference in the results, through the separation of cream, especially when the milk examined is rich.

Persons who have had no experience in the use of the pipette will do well to practice a short time by measuring water into a test bottle before attempting to make an analysis.

Of skim-milk or butter-milk take double the quantity (filling the pipette twice) and use the skim-milk test bottle (fig. 2).

With cream use the 18 cubic centimeter pipette and the cream test bottle, (fig. 3). The further proceeding is the same in all cases.

Adding the Acid.—After the milk has been measured into the test bottle the test may be proceeded with immediately, or the bottles may be left for a day or two without materially changing the results; samples that have remained in the test bottles two or three weeks and which had commenced to mould before the acid was added, have given the same amount of fat as samples tested immediately after being measured. If the milk has become coagulated, the curd should be broken up by shaking the test bottle before the acid is added. It is advisable, however, that the test be proceeded with immediately after the samples are measured, if possible.

The volume of commercial sulphuric acid required for a test is approximately the same as that of the milk, or 17.5 c. c. for the ordinary test. If too little acid is added, the casein is not all held in solution throughout the test, and an imperfect separation of the fat results. If too much acid is used, the fat itself is attacked. The acid need not be measured with great accuracy, as small variations will not affect the result.

Great care must be taken in handling the acid to avoid getting any of it upon the skin or clothing, as it is very corrosive. If by accident any is spilled upon the hands or clothes, it should be washed off immediately, using plenty of water. A prompt application of ammonia water to clothing upon which acid is spilled may prevent the destruction of the fabric, and restore the color.

When all of the samples of milk to be tested are measured ready for the test, the acid measure is filled to the 17.5 c. c. mark with sulphuric acid, and from this it is carefully poured into a test bottle, containing milk, that is held in a slightly inclined position for reasons given in directions for measuring the milk. The acid being much heavier than milk sinks directly to the bottom of the test bottle without mixing with the milk that floats upon it. The acid and milk should be thoroughly mixed together by gently shaking with a rotary motion. At first there is a precipitation of curd from the milk, but this rapidly dissolves. There is a large amount of heat evolved by the chemical action, and the solution, at first nearly colorless, soon changes to a very dark brown, owing to the charring of the milk sugar and perhaps some other constituents of the milk.

Whirling the Bottles.—The test bottles containing the mixture of milk and acid should be placed in the machine and whirled directly after the acid is added. An even number of bottles should be whirled at the same time, and they should be placed in the wheel in pairs opposite to each other, so that the equilibrium of the apparatus will not be disturbed. When all of the test bottles are placed in the apparatus, the cover is placed upon the jacket, and the machine turned at the proper speed for about five minutes. The test should never be made without the cover being placed upon the jacket as this not only prevents the cooling of the bottles when they are whirled, but in case of the breakage of bottles may protect the face and eyes of the operator from injury by pieces of glass or hot acid. The machine should be frequently examined to make certain that there is no slipping of belts or frictional bearings which may cause too slow motion and result in an imperfect separation of the fat. Managed in this way no extra heat is required, as that caused by the chemical action is sufficient to keep the fat liquid. If the bottles have stood, after the acid is added, until the contents are cooled below 100° F., they should be warmed to about 200° F. by placing them in hot water, before whirling.

Filling the bottles with hot water.—As soon as the bottles have been sufficiently whirled, they should be filled to about the seven per cent. mark, with hot water. If practicable, distilled or rain water should be used for the purpose. The bottles are most conveniently filled by placing a vessel containing boiling water above the machine, and by means of a siphon made from a small rubber tube with a glass tip, run the water directly into the bottles without removing them from the wheel. The flow of water can be perfectly controlled by a pinch cock upon the rubber tube. If only a few tests are to be made, the bottles may be easily filled with a pipette, or by pouring from a graduate. The cover should then be replaced and the machine turned for about one minute, after which the fat should be measured.

If, when managed in this way, clots of curd or other matter are mingled with the fat, making the reading uncertain, the difficulty can usually be avoided by adding the hot water in two portions, filling the bottle at first only to the neck and after whirling for about one minute adding sufficient hot water to bring the fat into the graduated neck, after which the bottle should be whirled and the fat measured.

Measuring the fat.—The fat when measured should be warm enough to flow readily, so that the line between the acid liquid and the column of fat will quickly assume a horizontal position when the bottle is removed from the machine.

Any temperature between 110° F. and 150° F. will answer, but the higher temperature is to be preferred. The slight difference in the volume of fat due to this difference in temperature is not sufficient to materially affect results.

To measure the fat, take a bottle from its socket, and holding it in a perpendicular position with the scale on a level with the eye, observe the divisions which mark the highest and the lowest limits of the fat. The difference between these gives the per cent. of fat directly. The reading can easily be taken to half divisions or to one-tenth per cent.

The line of division between the fat and the liquid beneath is nearly a straight line and no doubt need arise concerning the reading at this point but the upper surface of the fat being concave errors often occur by reading from the wrong place. The reading should be taken at the line where the upper surface of the fat meets the side of the tube and not from surface of fat in the center of the tube nor from the bottom of the dark line caused by the refraction of the curved surface. For instance in Fig. 6 the reading should be taken from *a* to *b* and not to *c* or *d*.

The reading may be made with less liability of error by measuring the length of the column of fat with a pair of dividers, one point of which is placed at the bottom and the other at the upper limit of the fat. The dividers are then removed and one point being placed at the 0 mark of the scale on the bottle used, the other will be at the per cent. of fat in the milk examined.

Sometimes bubbles of air collect at the upper surface of the column of fat and prevent a close reading; in such cases a few drops of strong alcohol (over 90 per cent.) put into the tube on top of the column of fat, will cause the bubbles to disappear and give a sharp line between the fat and alcohol for the reading. Whenever alcohol is used for this purpose, the reading should be taken directly after the alcohol is added, as after it has stood for a time, the alcohol partially unites with the fat and increases its volume.

Whenever the fat is not quite clear, more satisfactory results may be obtained by allowing the bottles to stand until the fat has crystallized and then warm them by placing the bottles in hot water, before taking the reading.

If the column of fat is less than about one division as will often happen with skim-milk, butter-milk or whey, it may assume a globular form instead of a uniform layer across the tube; when this occurs the fat can usually be estimated with sufficient accuracy by simple inspection, but in such cases it is better to take a double portion of milk in a large bottle.

The way of reading is illustrated in the figure. The bottom of the clear yellow liquid fat layer is at *a*. The upper surface is represented by *b*, *c*, *d*. The readings are 1.4 and 5.7. The difference, 4.3, is the per cent. of fat in this sample of milk.

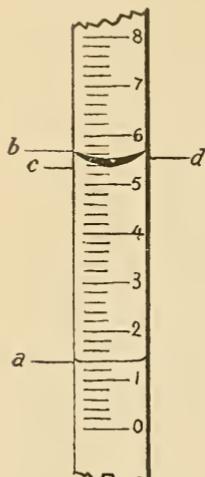


Fig. 6.

To the breeder of dairy stock, to the dairyman who wishes to keep only cows that it will pay him to keep, and to creameries, whether milk gathering or cream gathering, the Babcock tester can be of the greatest service.

It is beyond the purpose of the present Bulletin to discuss this part of the subject.

This Station is ready to coöperate with any creamery or dairyman, wishing further information or practical experience in working the method, and when necessary will send a representative who will give instruction in its use and the system of paying for milk or cream on the basis of butter fat.



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